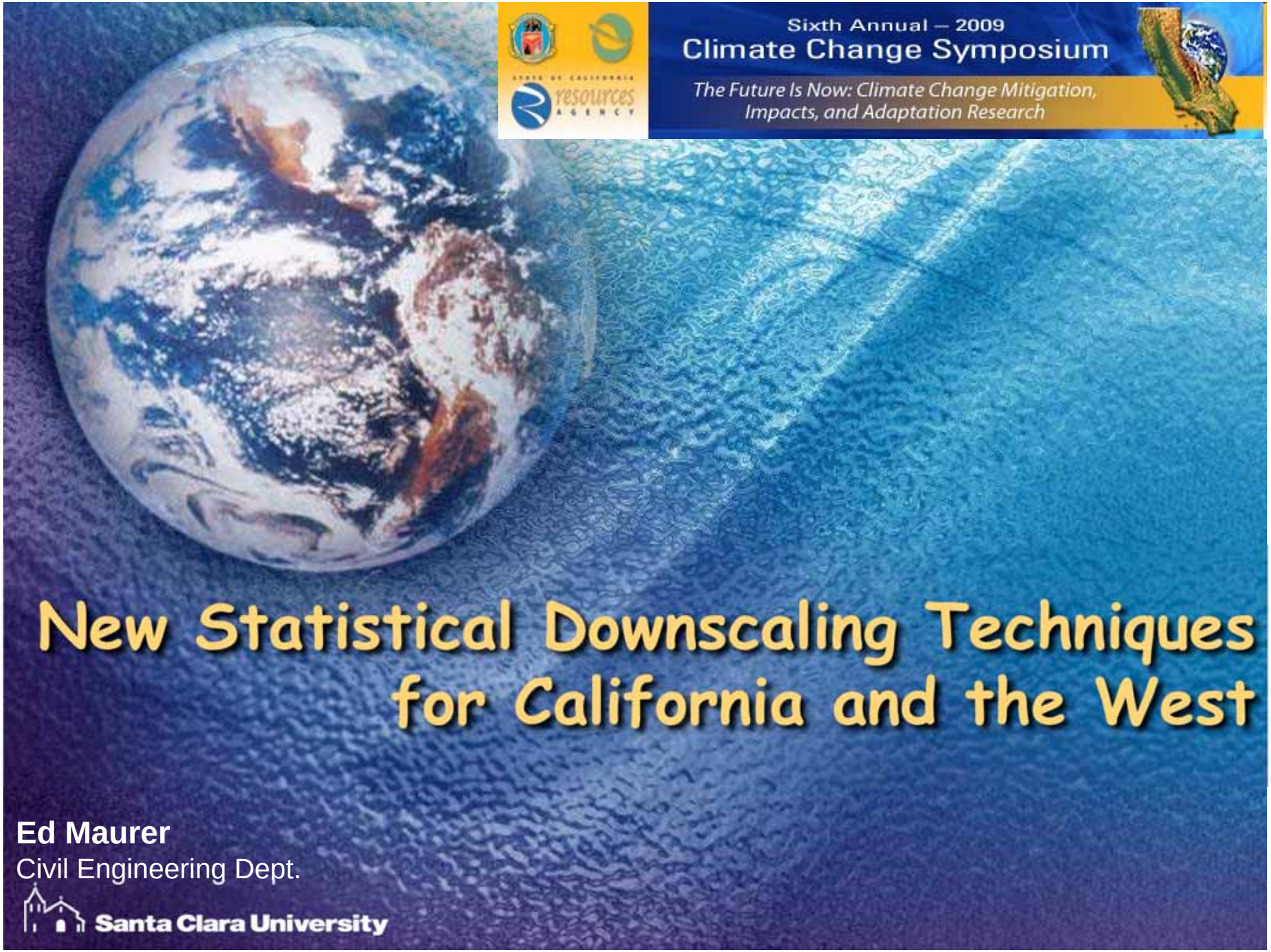
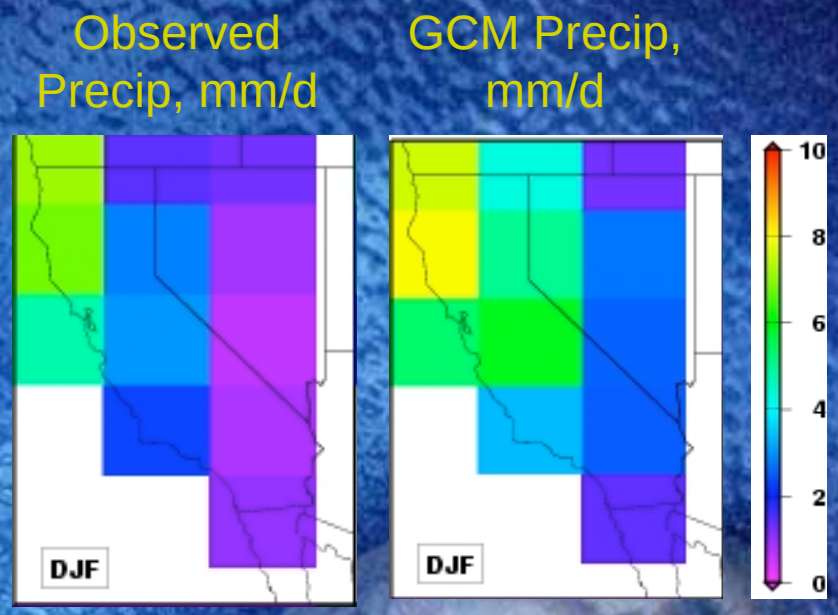
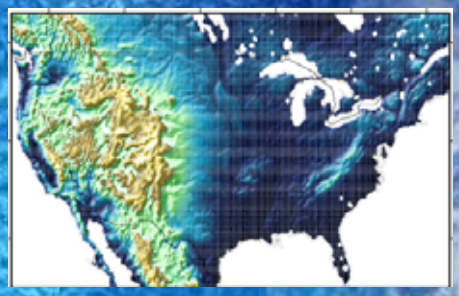
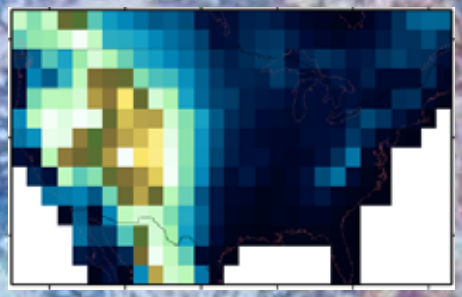

Sixth Annual – 2009
Climate Change Symposium
The Future Is Now: Climate Change Mitigation, Impacts, and Adaptation Research
resources
AGENCY
New Statistical Downscaling Techniques for California and the West
Ed Maurer
Civil Engineering Dept.
Santa Clara University

Projecting Future Climate - GCMs

- Climate Models (GCMs) Necessary
- These have biases
  - Spatial resolution
  - Parameterization
  - etc.
- At inappropriate scale for most impact analysis

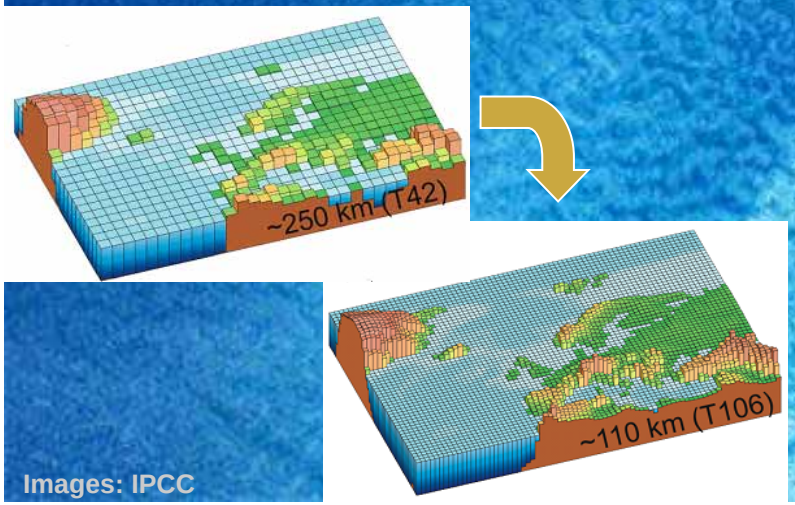






Need for Downscaling

- Dynamic
  - Better representation of terrain captures local processes and feedbacks
  - Computationally expensive
  - Still contain biases
- Statistical
  - Assumes stationary transfer function



Images: IPCC

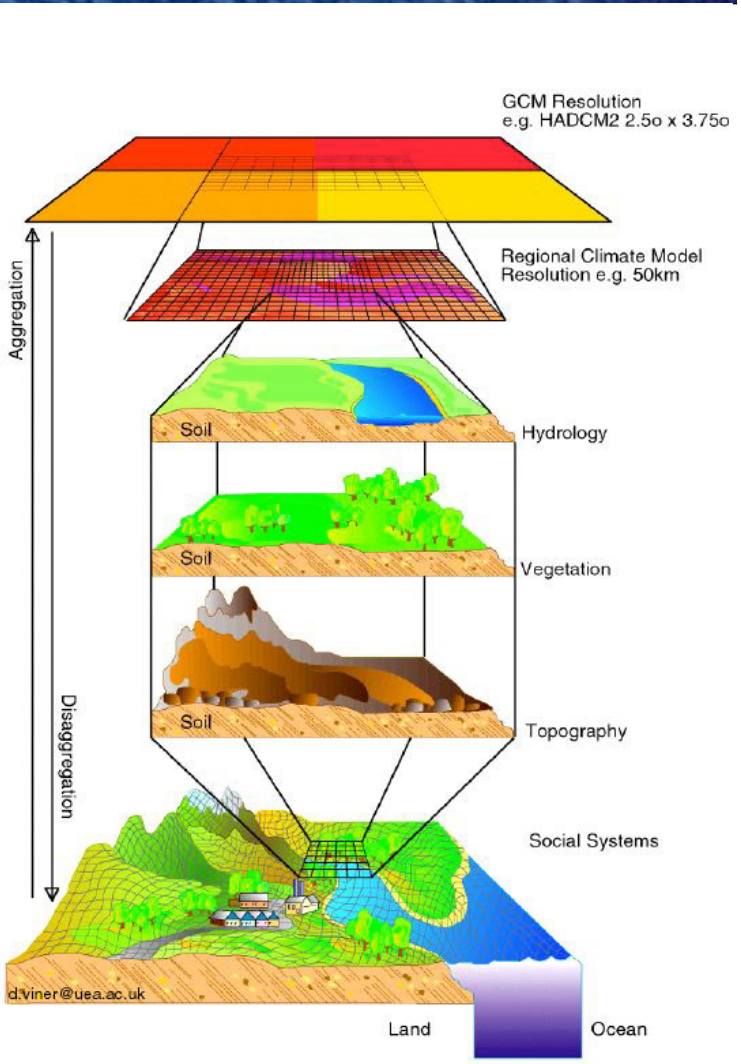
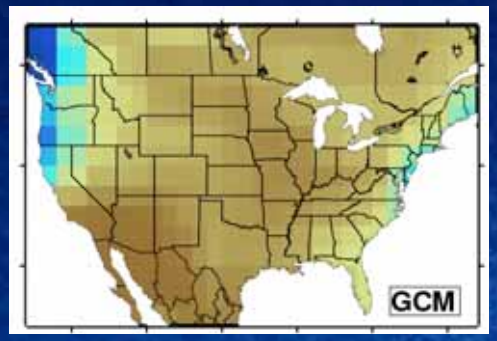
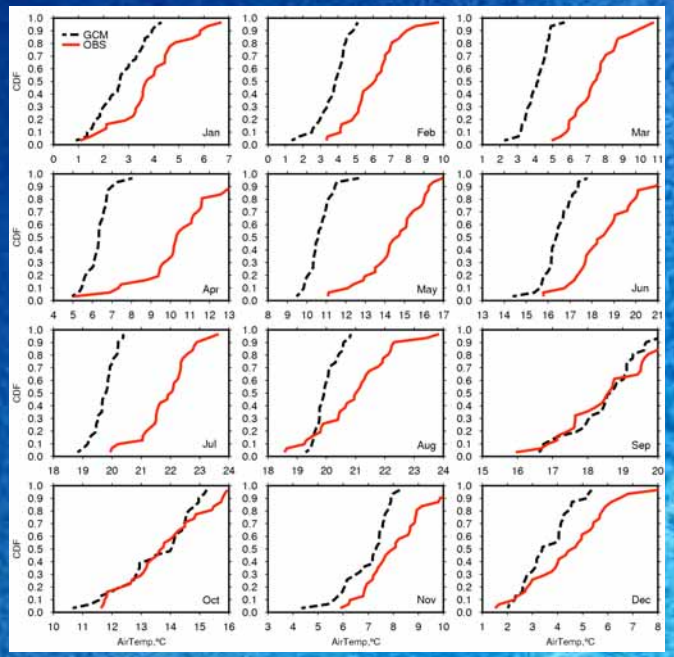


Image: Canadian Climate Change Scenarios Network

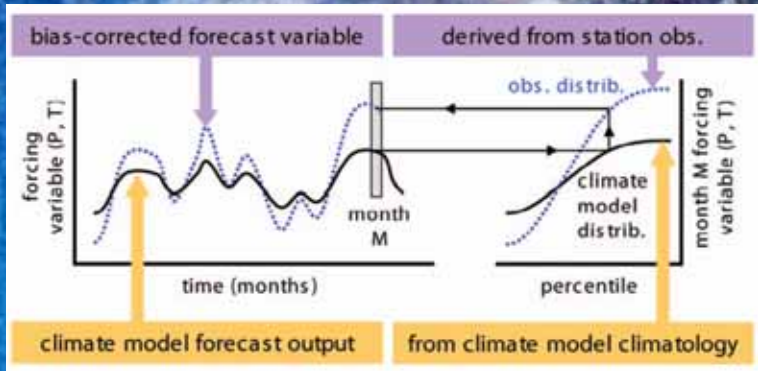
BCSD Method – "BC"



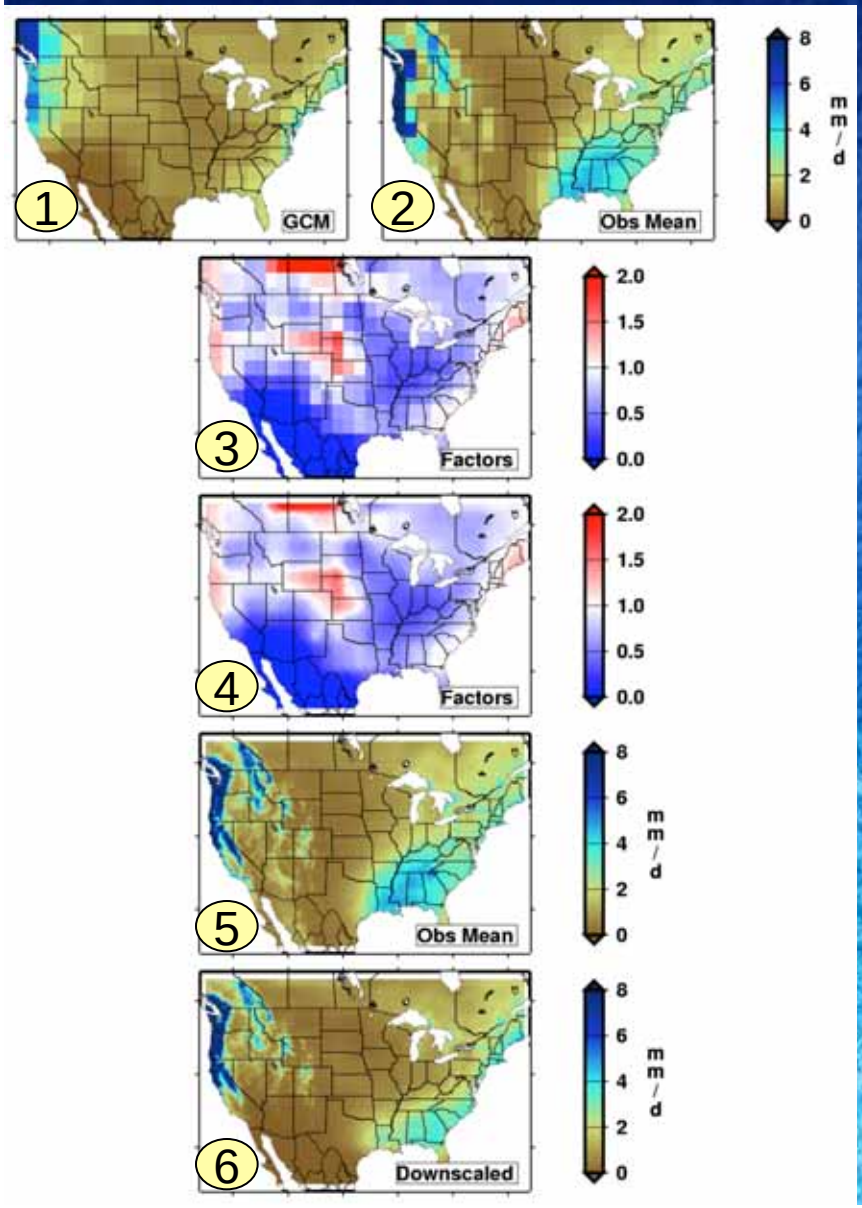
- At each grid cell for "training" period, develop monthly CDFs of P, T for
  - GCM
  - Observations (aggregated to GCM scale)
  - *Obs are from Maurer et al. [2002]*
- Use quantile mapping to ensure monthly statistics (at GCM scale) match
- Apply same quantile mapping to "projected" period



Wood et al., BAMS 2006



BCSD Method – "SD"



- Use bias-corrected monthly GCM output (1)
- Aggregate obs to GCM scale (2)
- Calculate P,T factors relative to coarse-scale climatology

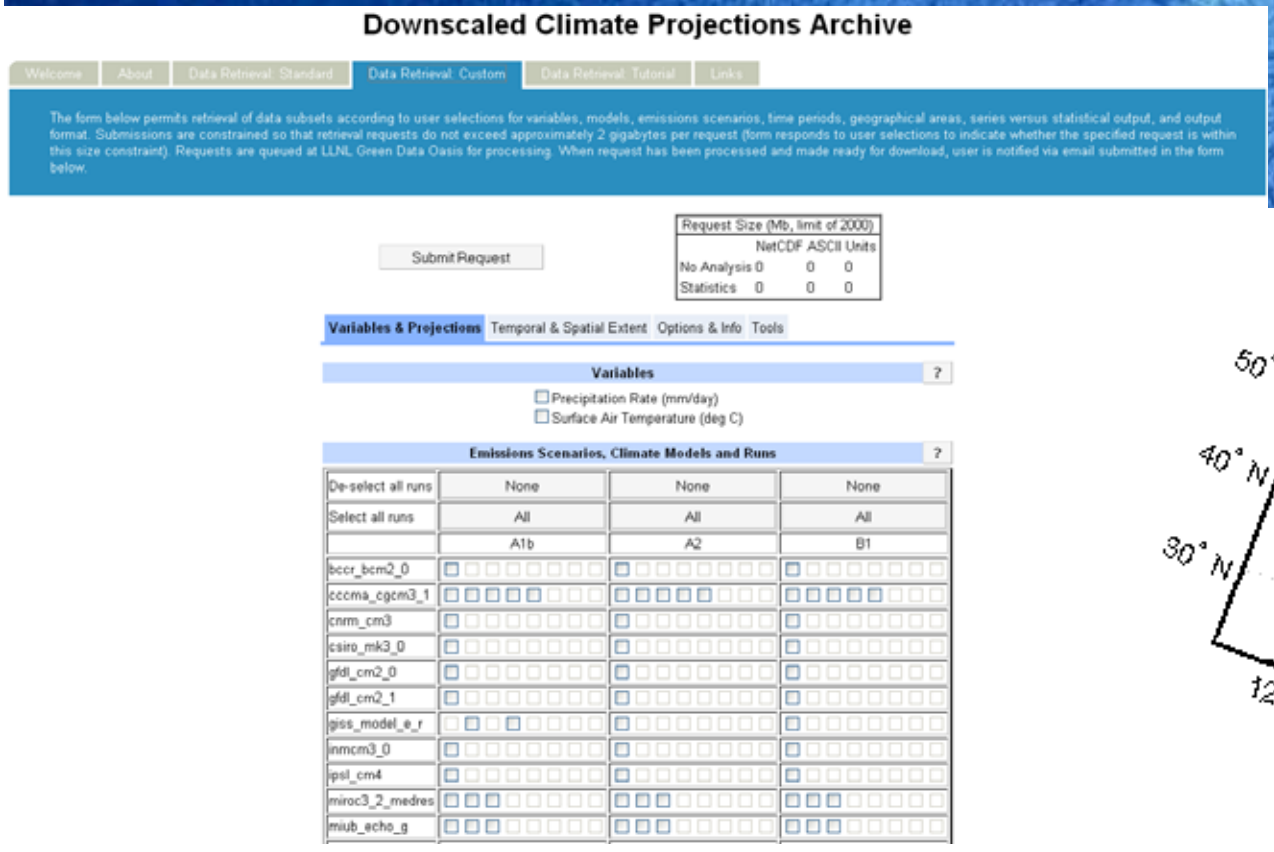
  (3) = (1) / (2) (P) (3) = (1) - (2) (T)
- Interpolate factors to 1/8° grid (4)
- Apply to fine-scale climatology

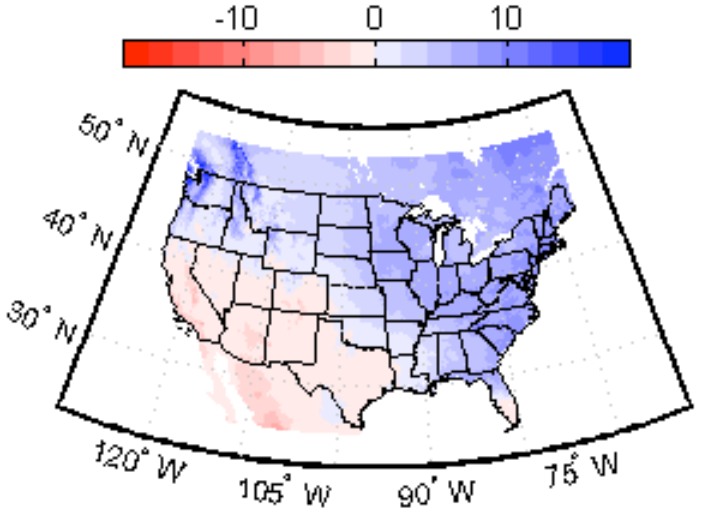
  (6) = (4) * (5) (P) (6) = (4) + (5) (T)

Daily Values from rescaled historical values

BCSD is Computationally Parsimonious

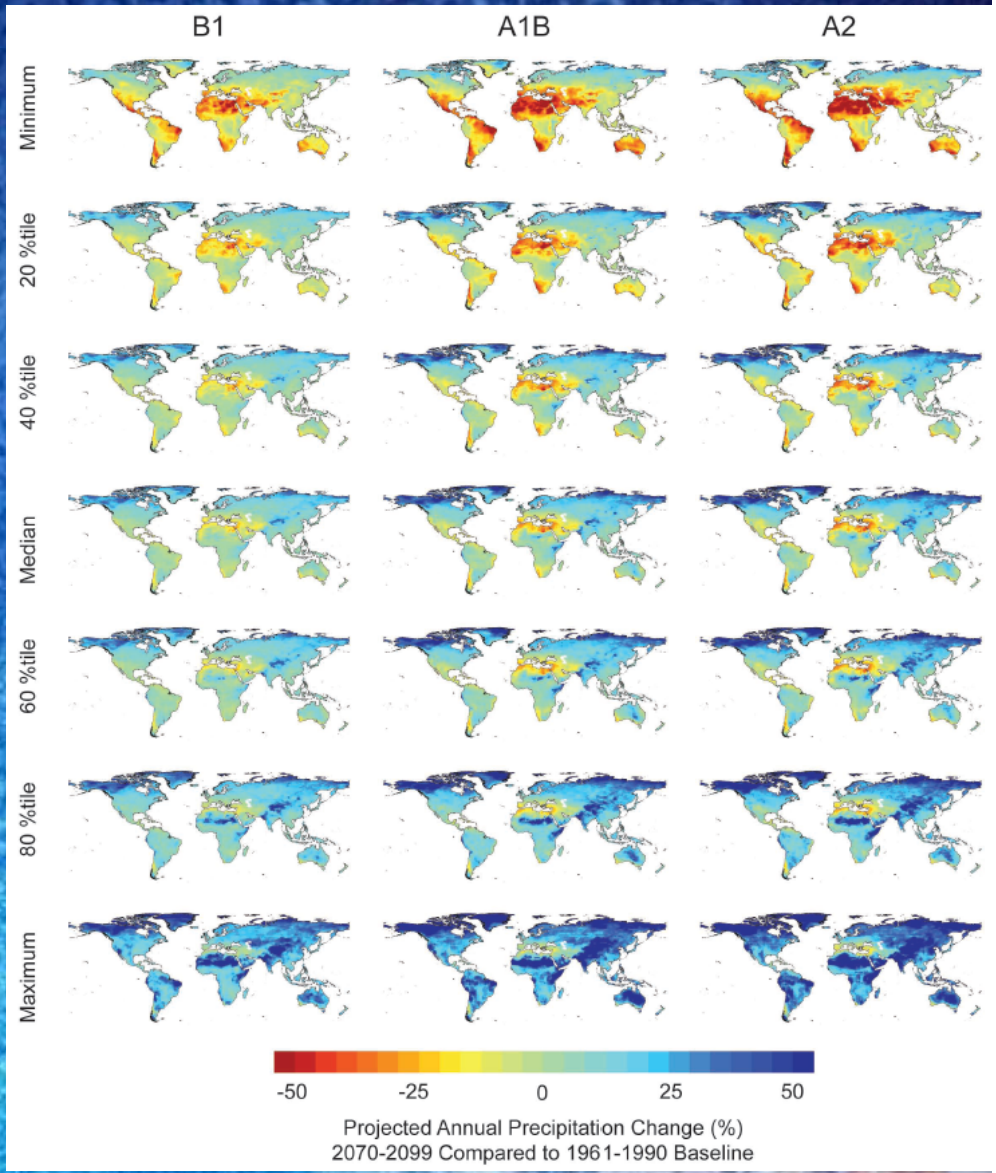
- PCMDI CMIP3 archive of global projections
- New archive of 112 downscaled GCM runs
- gdo4.ucllnl.org/downscaled_cmip3_projections
- Allows quick analysis of multi-model ensembles





Global BCSD

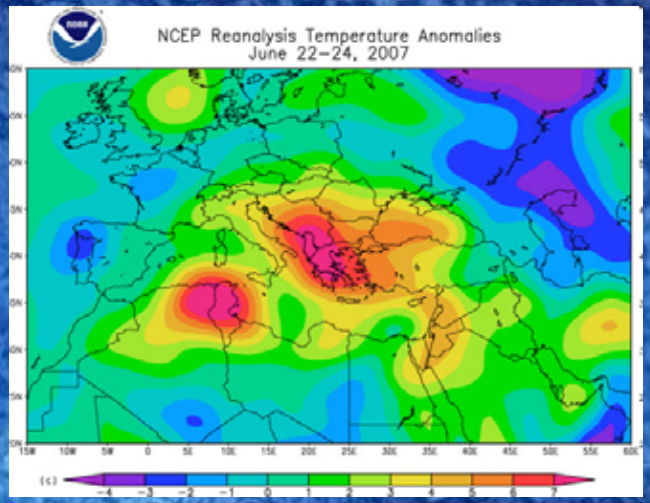
- Similar to US archive
- Allows probabilistic representation of projections
- Captures variability among GCMs
- http://www.engr.scu.edu/~emaurer/global_data/
- http://climatewizard.org/



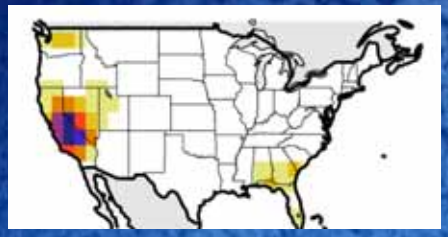
Source: Girvetz et al, PloS, accepted

Need for enhanced downscaling

- Some impacts due to changes at short time scales
- Heat waves
- Flood events
- BCSD limited

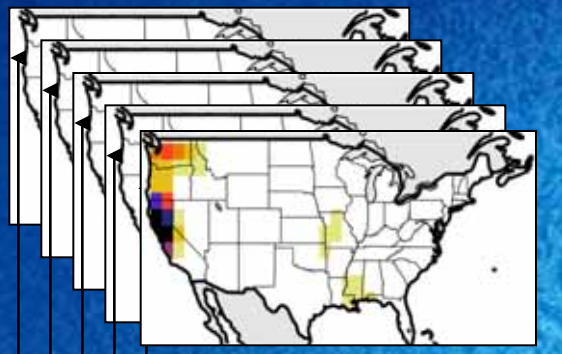


Constructed Analogues



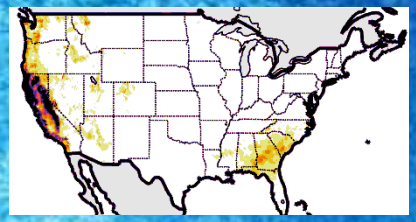
Given daily GCM anomaly

Library of previously observed anomaly patterns:



Coarse resolution analogue:

Analogue is linear combination of best 30 observed



Apply analogue to fine-resolution climatology

Can CA improve daily downscaled projections?

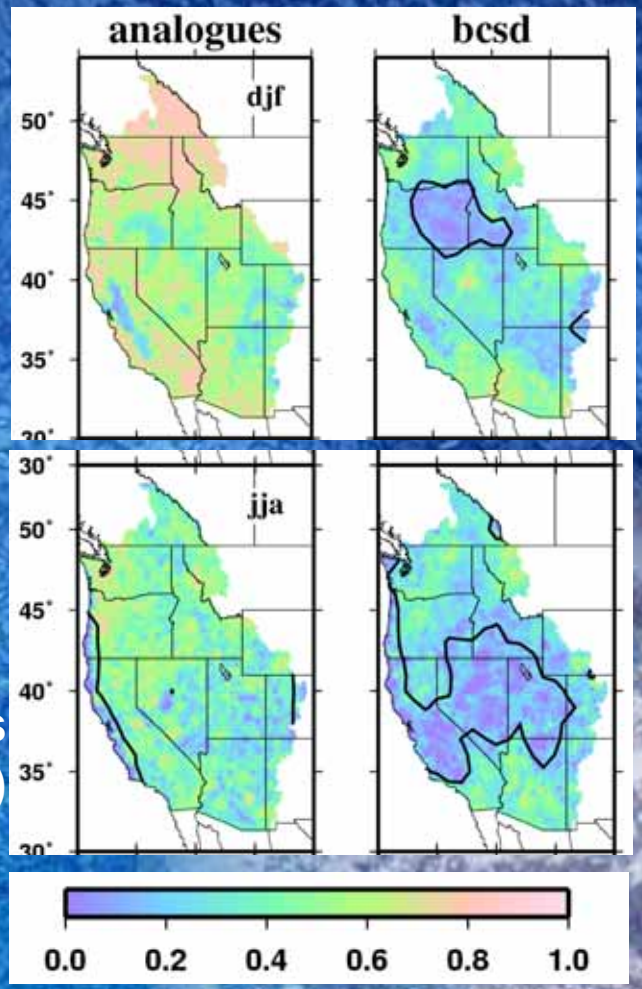
- Downscaled NCEP-NCAR Reanalysis for 1950-1999
- Use 1950-1976 as “observed”
- 1977-1999 as “projected”
- Monthly skill in reproducing Reanalysis P and T is high for both methods

Daily Temperature Extremes

- CA able to recover Reanalysis skill

Winter Cool Extremes (10 %tile daily T)

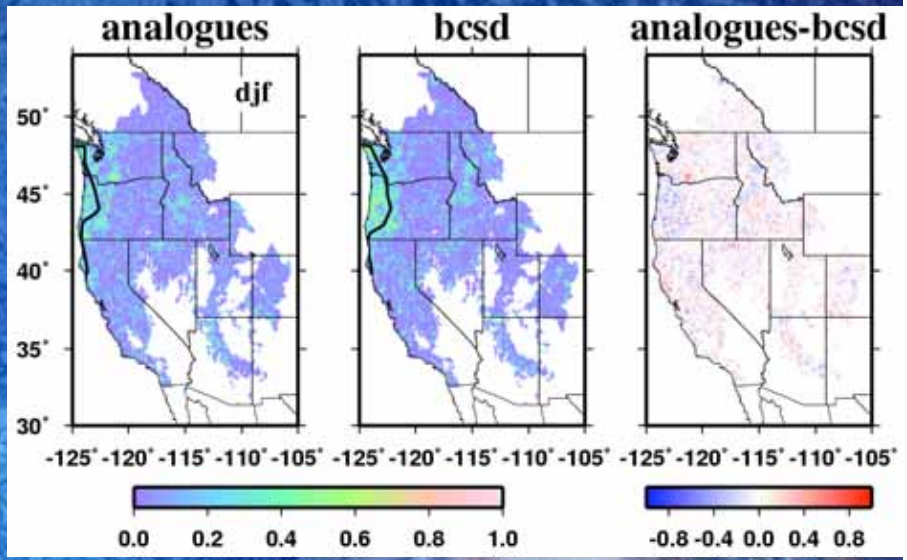
Summer Warm Extremes (90 %tile daily T)



Daily Skill: Dry Extremes

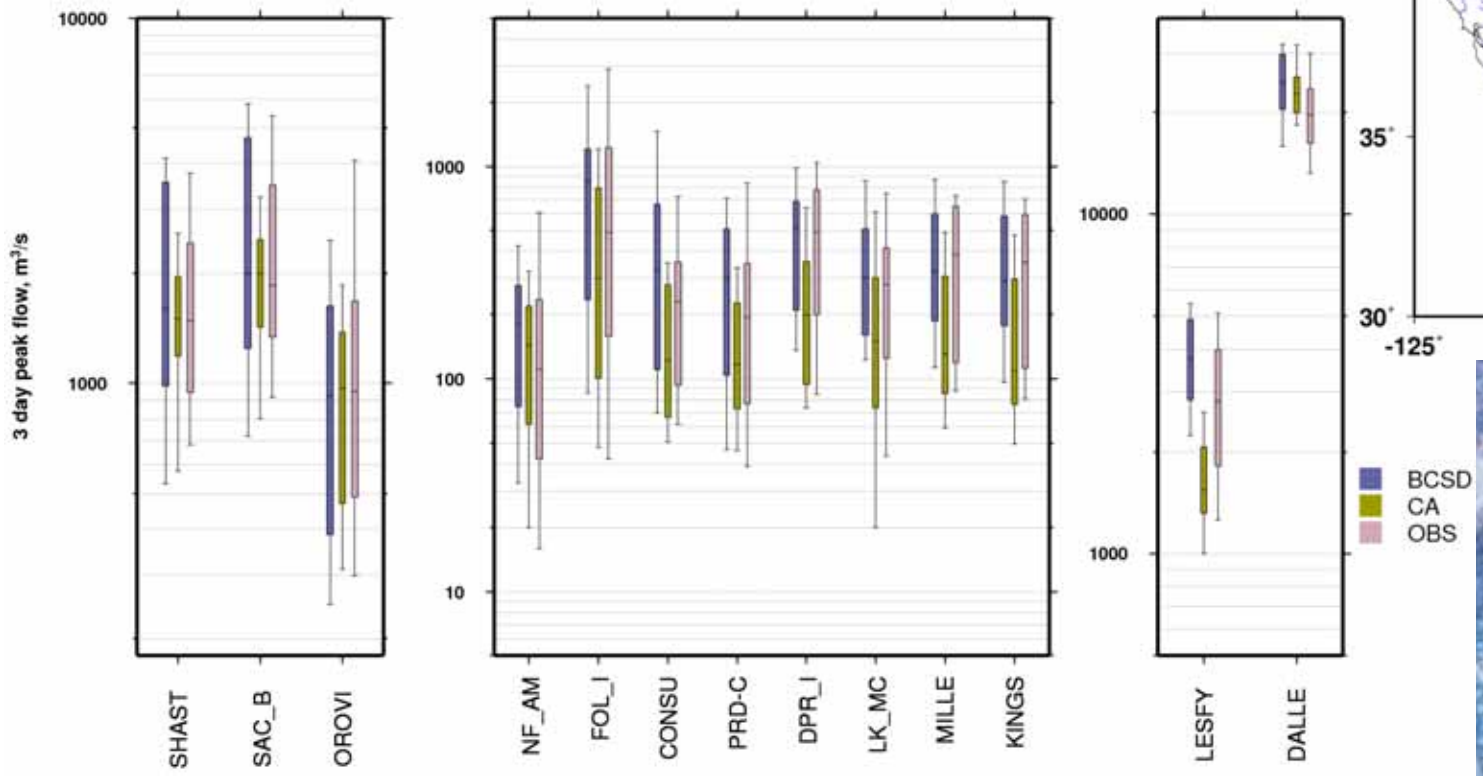
- 20th percentile winter P
- r^2 values shown
- 90% confidence line
- Low skill for both methods
  - Daily large-scale data cannot counter lack of skill, poor relationship between scales
- No statistical difference for CA, BCSD
- Similar results for wet extremes
- Difficulty downscaling dry extremes

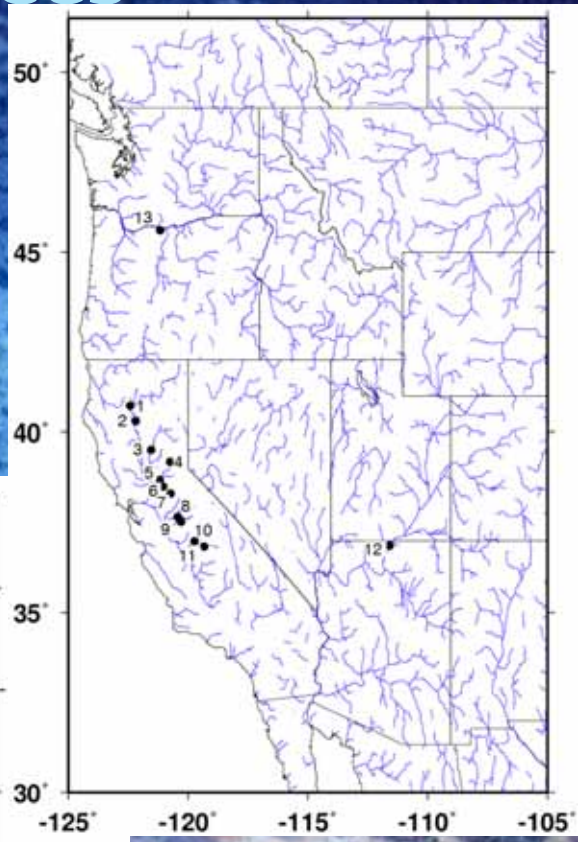
Dry Extremes (20 %tile daily P)

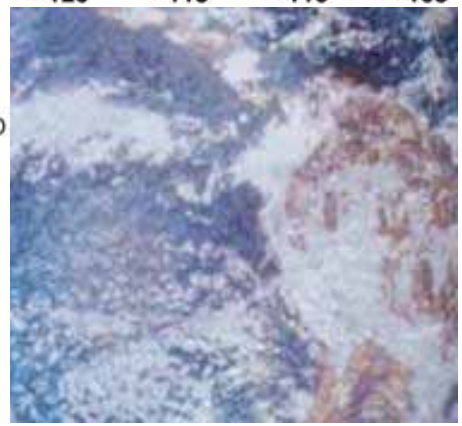


Peak Flow Differences

- Most sites comparable for both methods and Obs.
- Tuolumne R and Colorado R worse with CA than BCSD
- Room for improvement?





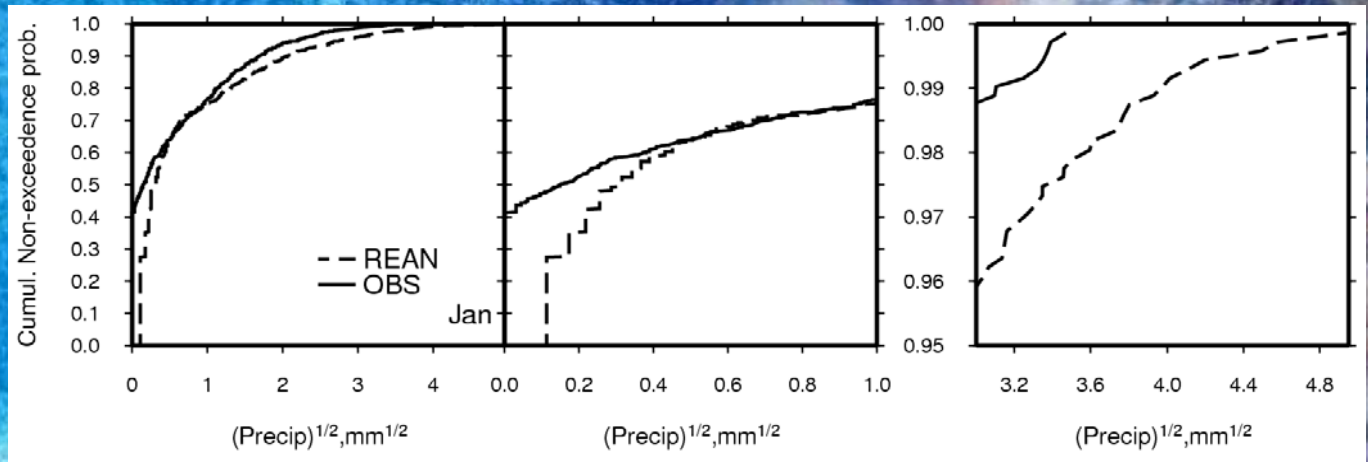


Differences between BCSD and CA

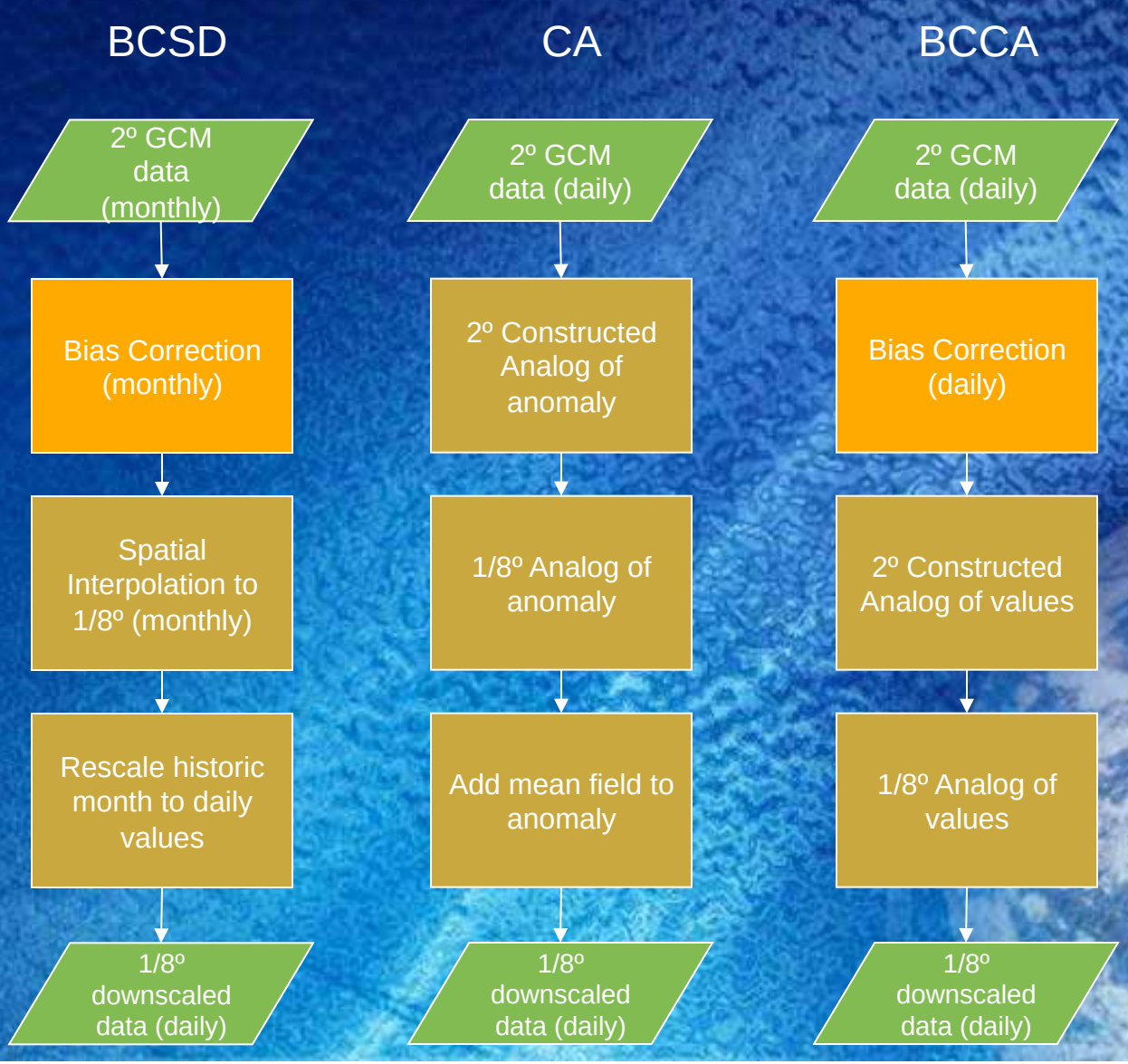
- CA uses daily GCM data; BCSD uses monthly w/random resampling to produce daily values
- BCSD explicitly corrects for systematic GCM biases based on historic GCM performance
- CA corrects mean bias (using anomalies) but not:
  - spatial GCM biases
  - variability biases

Looking in detail at one GCM cell

- At high and low extremes, reanalysis exhibits bias
- Accounting for bias in mean alone is insufficient
- Improvement: Bias correct daily GCM data prior to CA: BCCA
- Since BCCA is bias corrected, no need to anomalize

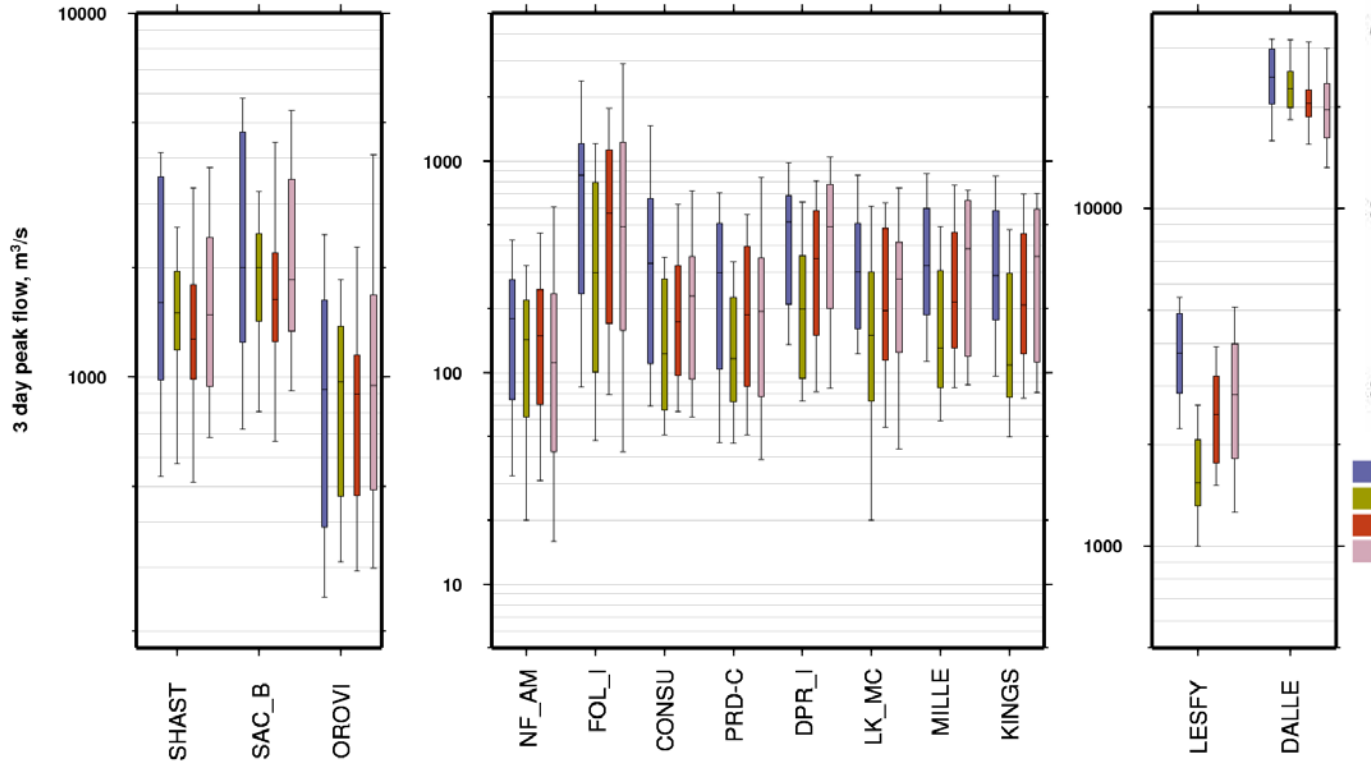


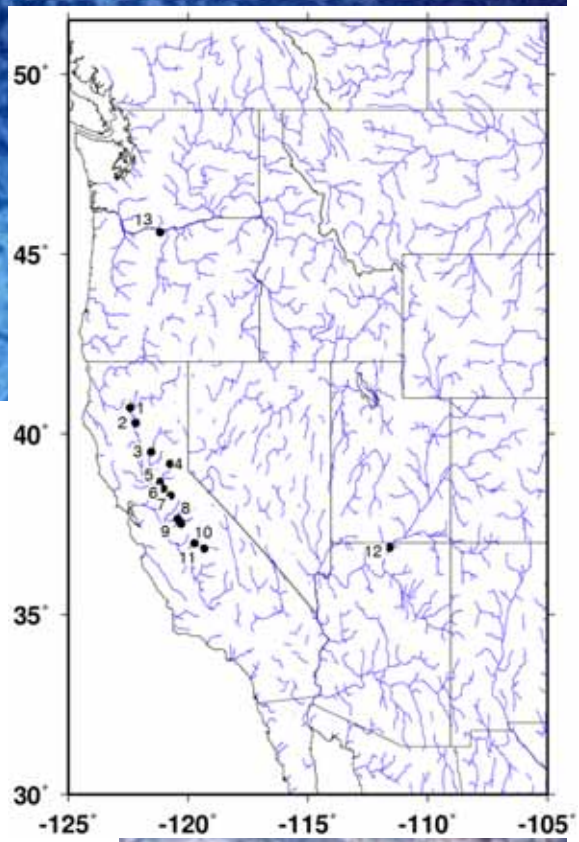
Schematic of Procedures

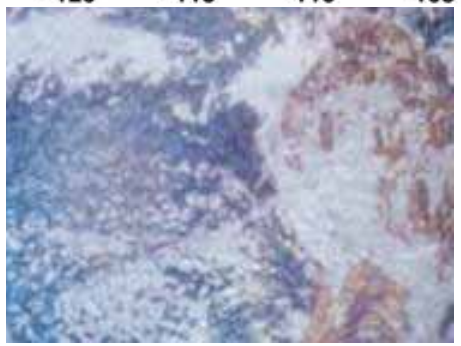


Effect of BCCA on Peak Streamflow

- Improvement with BCCA at most sites







Effect of BCCA

- Compared to CA, BCCA improves:
  - simulation of annual flow volumes
  - Simulation of flood peaks
- Problems remain for low flows, timing of snowmelt

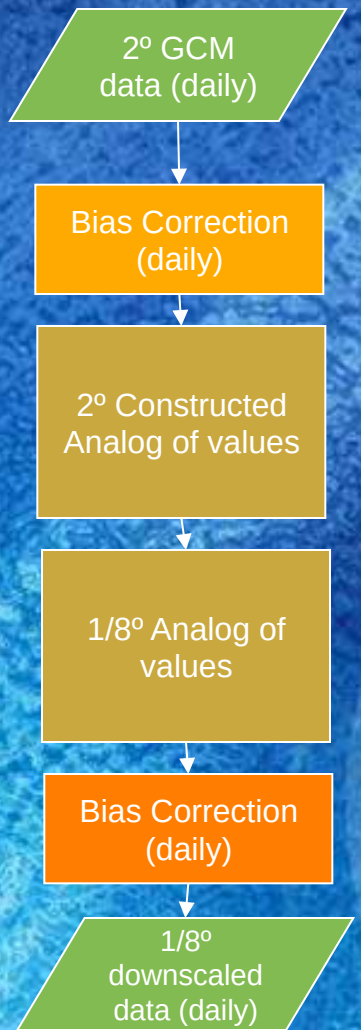
Highlighted indicates downscaled different from observed

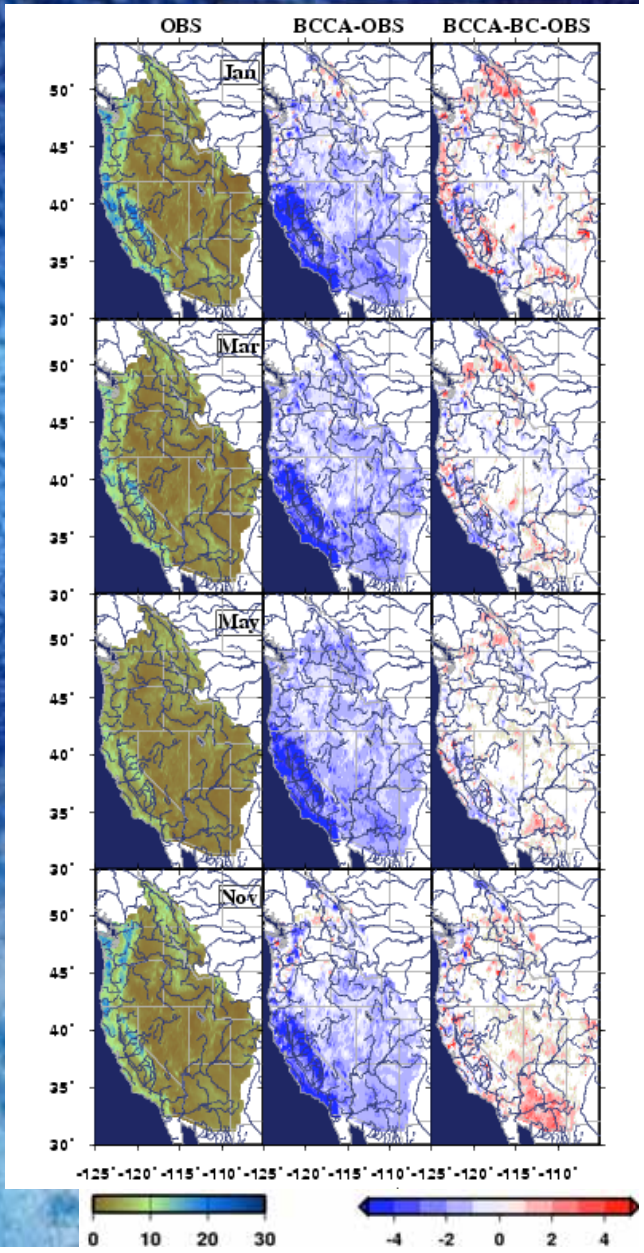
Center Timing			3- Day Peak			7-Day Low Flow			Annual Flow Vol.		
BCSD	CA	BCCA	BCSD	CA	BCCA	BCSD	CA	BCCA	BCSD	CA	BCCA
SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST
SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B
OROVI	OROVI	OROVI	OROVI	OROVI	OROVI	OROVI	OROVI	OROVI	OROVI	OROVI	OROVI
NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	**NF_AM**	**NF_AM**	**NF_AM**	NF_AM	NF_AM	NF_AM
FOL_I	**FOL_I**	**FOL_I**	FOL_I	FOL_I	FOL_I	**FOL_I**	FOL_I	**FOL_I**	FOL_I	**FOL_I**	FOL_I
CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	**CONSU**	CONSU
PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	**PRD_C**	PRD_C	**PRD_C**	PRD_C
DPR_I	DPR_I	DPR_I	DPR_I	**DPR_I**	DPR_I	DPR_I	DPR_I	**DPR_I**	DPR_I	**DPR_I**	DPR_I
LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC
MILLE	MILLE	MILLE	MILLE	MILLE	MILLE	MILLE	**MILLE**	MILLE	MILLE	**MILLE**	MILLE
KINGS	KINGS	KINGS	KINGS	KINGS	KINGS	KINGS	**KINGS**	KINGS	KINGS	**KINGS**	KINGS
LESFY	LESFY	**LESFY**	LESFY	**LESFY**	LESFY	**LESFY**	**LESFY**	LESFY	**LESFY**	**LESFY**	LESFY
DALLE	**DALLE**	**DALLE**	**DALLE**	DALLE	DALLE	DALLE	**DALLE**	**DALLE**	**DALLE**	DALLE	DALLE

Improvement on BCCA

- Downscaling evidently introduces additional bias
- Precipitation intensity has low bias
- Potential solution: second bias correction after downscaling
- As before, use 1950-1976 for training, 1977-1999 as “projected”

BCCA-BC





Conclusions

- Statistical downscaling has skill, especially at monthly level
- Some daily skill from large (GCM) scale can be translated to regional/local scale
- Bias-correction of large-scale signal improves skill
- Further refinement may be possible


Thanks!